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Roles of 2.5D Interactive Scenario Prototyping in Digital Experience Design Practice and Education

Kim, Han-Jong[a]; Nam, Tek-Jin*[a]

[a] Department of Industrial Design, KAIST, Daejeon, Republic of Korea
* tjnam@kaist.ac.kr

Digital experience design, involving various digital products, systems, and underlying services, has become a popular subject matter in design. Prototyping in the early stage is an important activity because it allows designers to concretize and deliver their ideas of future experiences. In digital experience design, however, prototypes are fragmented into diverse means, such as physical, visual, and sequential forms. In this paper, we present a 2.5D interactive scenario prototyping tool for facilitating the synthetic design of digital experience in the early phases. The tool allows designers to easily and rapidly create 2.5D interactive scenarios using 2D sketches (of spaces, artifacts, and mobile interfaces) and 3D character animations (for users' movements, gestures, and emotions) while specifying users' spatiotemporal journeys. We released the tool via public Web to readily support design practice and education. From the interview study with seven design experts, we identified the potential leverage of 2.5D interactive scenario prototyping that enables synthetic, synergic, and collaborative design. We then discuss further issues regarding the tool's engagement in design practice and education.

Keywords: digital experience, design scenario, prototyping tool, user experience, service design, expert interview

1 Introduction

Recently, subject matters of design have been diverse as various digital products and systems have appeared. The interactive products and systems have widely spread into our everyday lives so that we can enjoy beneficial and convenient experiences. Such experiences served by diverse digital artifacts involve not only the physical and virtual interfaces but also their underlying services. For instance, recent online-to-offline services (e.g., marketplaces, car-sharing, and hospitality) provide an experiential journey to users through various digital components, including mobile apps, kiosks, public displays, and smart sensors. To derive beneficial digital experiences for users, it is essential to envision the comprehensive experiences in the early conceptual design. How can we effectively concretize and deliver such sophisticated experiences?

In the service design domain, customer journey maps and service blueprints are common methods to illustrate specific experiences of target users. They, however, present difficulties in addressing the apparent and interactive aspects of service components for digital experiences. Buchenau and Suri (2000) presented *experience prototyping* that represents a process of conveying an experience with a product, system, and environment. Currently,

prototypes for digital experiences have fragmented into various means according to the target purposes—for example, physical prototypes, interface mock-ups, service blueprints, and storyboards. It is necessary to discover an experience-prototyping tool for deriving integrated design deliverables involving interactive artifacts and service flows.

We focused on adopting scenario-based prototyping (Rosson & Carroll, 2002) to concretize and deliver digital experiences. In this paper, we present a scenario-prototyping tool, SketchStudio, for creating 2.5D interactive scenarios. The tool facilitates creating an interactive, animated scenario in a virtual world from spatiotemporal journeys, simple 2D graphics, and 3D character animations. Based on our previous study of the tool (Kim, Kim, & Nam, 2018), we revised SketchStudio to be ready to use for designing various experiential subjects involving interactive artifacts and service journeys. Specifically, we updated the tool to effectively support digital experience design by adding interactivity to users' experience flows; it also enables diverse scales of sketches from environmental features to mobile interfaces. The tool was implemented to be fully operated via public Web so that designers can freely use it (http://sketchstud.io).

This paper also presents implications of 2.5D interactive scenario prototyping in digital experience design through reflecting on SketchStudio. From interviews with seven design experts, we report the leverage and advantages of 2.5D interactive scenarios as well as improvement areas while understanding the nature of design practice and education. The interview study reveals that such scenario prototyping has the potential to facilitate the synthetic design of multiscale experiences regarding users, systems, interactions, and physical environments. It also presents the importance of symbiotic prototyping with other means to create synergies throughout the entire design process. We also found that the tool is applicable to effectively support the interdisciplinary nature of experience design. We further discuss issues regarding the tool's usage and adoption in design practice and education.

2 Related Works

2.1 Storyboard-based Prototyping in the Ubicomp Domain

In the ubicomp domain, one approach for envisioning complicated experiences involving ubiquitous systems is using storyboards instead of technical implementations. The storyboard metaphor allows designers to intuitively deal with the interactions by describing states and situations. *BrickRoad* (Liu & Li, 2007) and *Topiary* (Li, Hong, & Landay, 2004) are tools for simulating mobile interfaces for location-based systems using interactive storyboards controlled by Wizard of Oz technique. Li and Landay (2008) presented *AcitivityDesigner*, a prototyping tool for modeling human activities in which the interface transitions can be composed of storyboards and triggered by the activity events. *DemoScript* (Chi, Li, & Hartmann, 2016) adopts storyboard-based illustrations for prototyping cross-device interactions among mobile and wearable systems. The storyboards succinctly depict the conditions and responses of the system (Dow, Saponas, Li, & Landay, 2006) so that it has the potential to specify complex experiences within interactive systems. Previous prototyping tools focused on using 2D storyboards to manage the transitions of system states. We extend such a feature of storyboards to convey the comprehensive narrative of interactions in digital experiences implemented in a 2.5D virtual world.

2.2 Sketches in Interactive Prototyping

Sketches are a familiar means of prototyping for designers to concretize and deliver ideas rapidly at a higher representation level. Several design tools have attempted to enable sketches to depict the dynamic and interactive attributes of digital products and systems. *DEMAIS* (Bailey, Konstan, & Carlis, 2001) and *Anecdote* (Harada, Tanaka, Ogawa, & Hara, 1996) are sketching tools for designing the content and interface of interactive multimedia by using the metaphor of a 2D paper sketch. Beyond the context of media production, interactive sketches can be found in tools for software design or interactive product design. *SILK* (Landay & Myers, 2001), *DENIM* (Lin, Newman, Hong, & Landay, 2000), and *STCTools* (Nam, 2005) enable the rapid prototyping of interactive products by using sketches and their state transitions. These prototyping tools enable designers to compose high-fidelity interactive prototypes with only rough sketches, which have a similar purpose to paper prototypes. In this research, we adopted 2D sketches for visualizing people and artifacts as well as their states and interfaces. The transition of sketches is adopted to represent not only spatial configurations of environmental artifacts but also experiential contexts including behaviors and emotions.

2.3 Virtual 3D Prototyping for Interactive Simulations

Some studies have used 3D animations and simulations to visualize detailed experiences for large-scale systems and services. Winterbottom and Blake (2008) presented a tool for designing interactions in virtual 3D environments simulating complex interactions. It features a simple floorplan view and authoring scheme of sequence diagrams to construct the virtual interactive environment. Xu, Creighton, Boulila, and Bruegge (2012) adopted the virtual world platform *OpenSim* to create a design scenario on an airport scale. *DollhouseVR* (Ibayashi et al., 2015) is a collaborative interior design system that supports real-time immersive review with virtual reality. In several studies, the *Unity3D* game engine was adopted for building- and city-level designs (Cristie, Berger, Bus, Kumar, & Klein, 2015; Kumar, Hedrick, Wiacek, & Messner, 2011). These virtual prototyping techniques are inefficient in the early design phases because constructing virtual 3D content requires significant time and effort, involving 3D asset modeling and programming. In this research, we applied 2.5D interactive scenarios in virtual worlds, using simple 2D sketches and premade 3D human characters, to support rapid prototyping for large-scale subjects.

2.4 Animatics Design

This research is related to the techniques conveying experiential narratives, which is called animatics design. Several commercial tools exist for creating animatics and storyboards for comics, animations, and films. Clip Studio Paint[1] is a professional drawing tool for comics that includes a specialized feature for 3D assets for human poses. Toon Boom Storyboards Pro[2] provides frameworks for organizing flow and camera walk for creating animations. ComiPo[3] supports the rapid creation of comic-style storyboards using blending 3D characters, background images, and visual effects. Some storyboarding tools, FrameForge[4] and PowerProduction Storyboard[5], enable filmmakers to rapidly produce storyboards using

[1] CELSYS, Inc. Clip Studio Paint. Retrieved from https://www.clipstudio.net

[2] Toon Boom Animation Inc. Storyboard Pro. Retrieved from https://www.toonboom.com/products/storyboardpro

[3] Web Technology Corp. ComiPo. Retrieved from https://www.comipo.com

[4] Innoventive Software, LLC. FrameForge 4. Retrieved from https://www.frameforge.com

[5] PowerProduction Software. Storyboard Apps. Retrieved from https://www.powerproduction.com

premade 3D actors and props before actual shooting. Several studies support designers in creating interactive and immersive animatics. Henrikson, De Araujo, Chevalier, Singh, and Balakrishnan (2016a) presented a multi-device storyboarding system for the early sketches of cinematic narratives in virtual reality. It adopted concentric cylinders as a sketching plane for rendering panoramic storyboards. *Storeoboard* (Henrikson, De Araujo, Chevalier, Singh, & Balakrishnan, 2016b) enabled the creation of early animatics for stereoscopic media by using multiple stacked planes. These offer the ability to provide an immersive review of early narratives with 3D attributes.

The aforementioned tools facilitated the creation of animatics and storyboards to deliver a certain narrative. However, they involved fewer considerations regarding the spatial conditions and dynamics of users and surroundings to be used for digital experience design. In our research, we aimed to concretize and deliver narratives dealing with entire contexts, including the details of spatial layouts and simultaneous interactions among people and digital artifacts.

3 Revised SketchStudio for Digital Experience Design

To support the early conceptual design of digital experiences, involving multiple users and digital artifacts, we present SketchStudio, an exemplary scenario prototyping tool. It is a Web-based tool for rapidly creating a 2.5D interactive scenario using simple 2D sketches and 3D human characters (Figure 1). It was evolved from our previous study (Kim et al., 2018) to be usable in actual design practice and education. We also revised the previous version with new features to effectively support scenario prototyping in digital experience design. SketchStudio was released for free use on the following domain in August 2018: http://sketchstud.io.

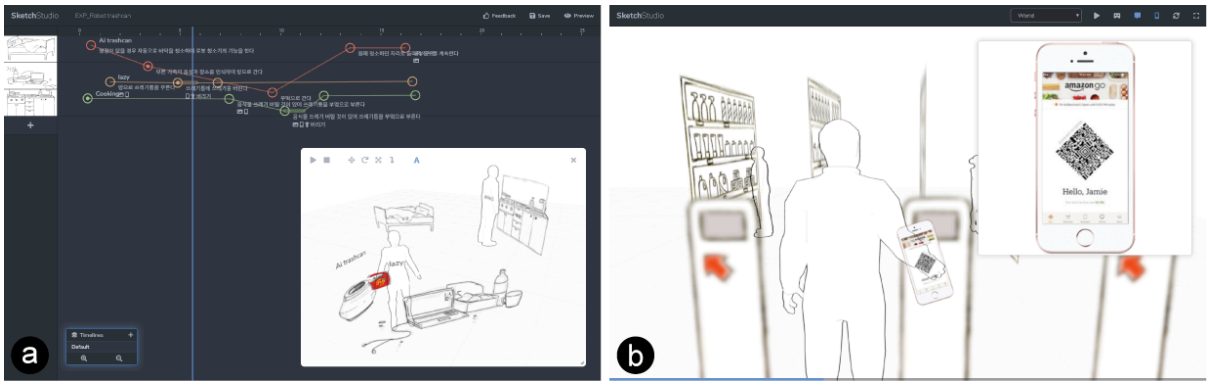

Figure 1. Snapshots of SketchStudio*: (a) the Editor and (b) the Viewer applications.*

3.1 Update of System Features

The previous version of SketchStudio (Kim et al., 2018) was designed to compose a virtual animated scenario by defining the spatiotemporal journey with a node graph. Blending of 2D sketches and 3D character animation was adopted for effective construction and visualization of a virtual 2.5D space. It also allowed designers to experience the created scenario using virtual reality in early conceptual stages. Based on the previous study, we identified several limitations in the expressiveness of experiences, including in representing small artifacts or precise actions. We designed and implemented several additional features for SketchStudio for digital experience design. The new version supports *keyframe-based*

pose editing—instead of recording with the mobile interface—to get detailed actions for human characters. It also supports *portable sketches* for representing small, handheld artifacts including mobile devices carried by users. Moreover, the new version allows designers to assign interactivity to scenario streams so that they can explore various alternatives within a scenario prototype. The tool's interface was also updated to integrate fragmented components into two main applications—the Editor and Viewer (as shown in Figure 1)—for better work efficiency. The details of five key features and how they were updated in the scope of this work are described in Table 1.

Table 1. Five key features of SketchStudio

Features	Details	Updates
Spatiotemporal Experience Authoring	This enables specifying a spatiotemporal experience flow using node graphs (Figure 1a). A node, located on time-object dimension, represents which person interacts with which object at which moment. The system automatically generates an animated scenario according to the composed node graphs.	Same as the previous version.
Active 2.5D Sketches	To construct a scenario scene rapidly, simple 2D sketches can be located in 3D virtual space. The sketches can be continuously replaced for dynamic representation of artifacts (interface) and people (context), as shown in Figure 2b.	Drawing a portable sketch representing a handheld-sized artifact was added (Figure 2c).
Hybrid Action Creation	This supports creation of high-resolution character animation with two modes: rigging with virtual joysticks and keyframe-based pose editing. The created actions can be assigned to the node and triggered while playing the scenario.	The action-creating application was integrated into the main Editor application.
Interactive Scenario Stream	This adopts a stacked timeline, inspired by the concept of the parallel universe, for assigning interactivity to the animated scenario. It switches the timelines to make one visible according to the decision at a specific moment (Figure 2a). This approach has been used in interactive storytelling for various media such as games and films (Glassner, 2004; Miller, 2014).	Newly added.
Immersive VR Playback	This renders the virtual scenario in the third-person view while chasing the target human character (Figure 1b). Using Google Cardboard with a smartphone provides an immersive experience to review the initial ideas from the potential stakeholders' perspectives.	Same as the previous version.

3.2 Prototyping Steps.

Scenario prototyping with SketchStudio consists of five major steps: creating spatial objects, composing spatiotemporal experiences, specifying states, adding interactivity, and playing the scenario. The overview of the prototyping steps is illustrated in Table 2 and Figure 3. Figure 3 shows the process to create an exemplary digital experience scenario, a smart ordering service (illustrated in Figure 2)—related to kiosks and smartphones—in a café.

Table 2. Activities in prototyping steps

Steps	Activities
Creating Spatial Objects	• Drawing sketch objects and locating them in virtual 3D space.
Composing Spatiotemporal Experiences	• Composing a node graph for each human character. • Specifying the characters using sketches.
Specifying States	• Creating character actions and assigning each action to the composed nodes. • Assigning sketches to each node to visualize contextual information around a human character. • Assigning portable sketches to each node to represent states of small-scale handheld artefacts. • Adding overlaid sketches for visualizing states of the sketch objects at specific moments.
Adding Interactivity	• Composing the alternative timeline streams. • Adding triggers at certain moments for shifting timelines
Playing the Scenario	• Playing the created scenario while navigating the virtual 3D space. • Selecting a human character to follow during playback. • Using Google Cardboard for an immersive experience from the target character's viewpoint.

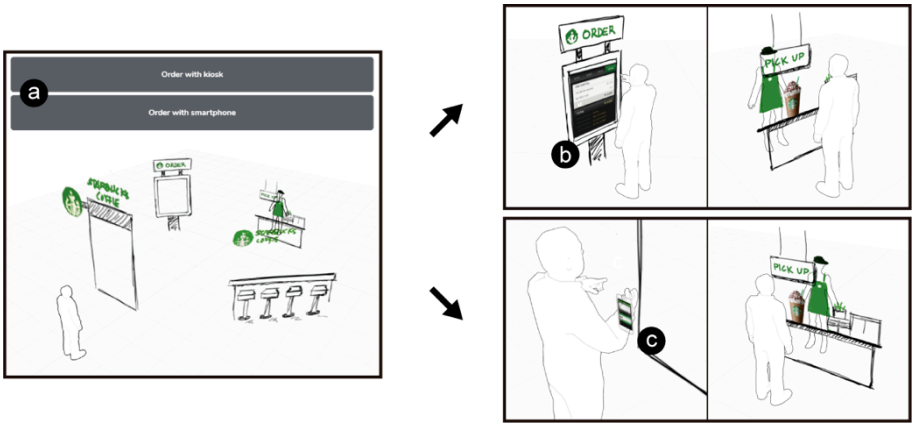

Figure 2. Exemplary digital experience scenario of smart ordering service created by SketchStudio.

4 Roles of 2.5D Interactive Scenario Prototyping

After releasing SketchStudio, it was necessary to discover how the tool can be actively adopted in real design activities. The goal of this study was to understand the roles of 2.5D interactive scenario prototyping in digital experience design practice and education. We interviewed design experts to identify potential leverage and advantages of such prototyping in real contexts through reflecting on the exemplary tool. The design experts including practitioners and professors described several strategies the tool can involve in design practice and education regarding digital experiences.

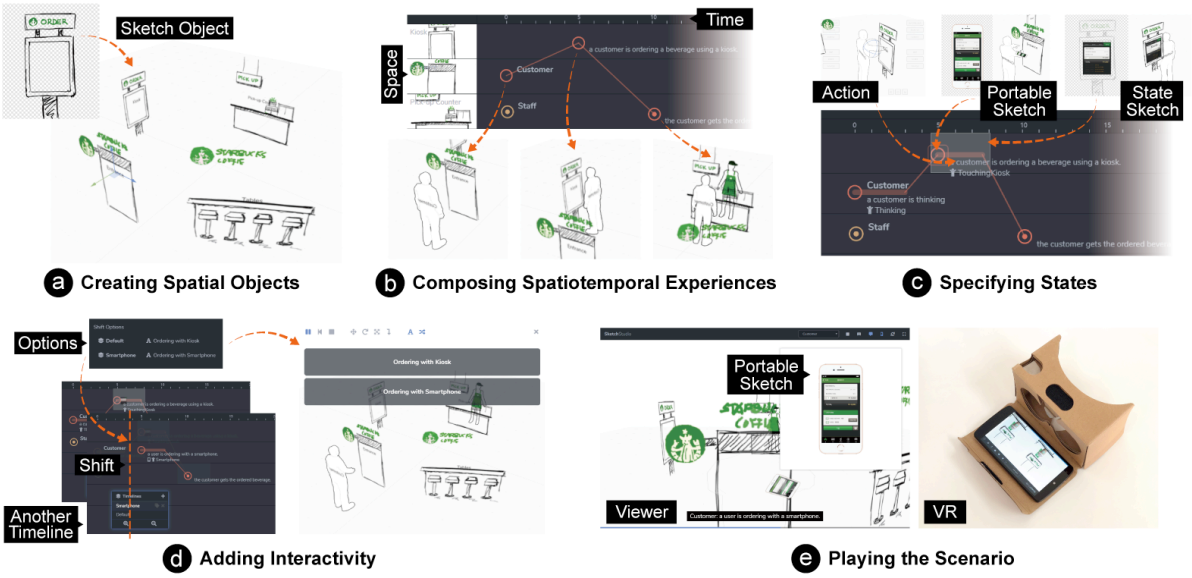

Figure 3. How a 2.5D interactive scenario can be created using SketchStudio.

4.1 Design Experts

Seven design experts were recruited for the interviews. Four were professional design practitioners at a design agency, working across the domains of strategy, product innovation, and user experience. Three were professors in universities' design-related departments, involving service design, interactive product design, and design-convergence innovation. The experts had commonly experienced various design projects related to envisioning future digital experiences using various design methods and tools.

4.2 Method

We carried out in-depth interviews with the design experts at their workplaces. The experts briefly explained their working and teaching approaches in terms of methods and tools in early conceptual design. We then introduced SketchStudio's key features and demonstrated them with several example scenarios regarding conceptual digital experiences. The main topic of the interview was the tool's applicability for resolving existing challenges in real design practice and education. We also asked about the expected application domain and further improvement areas of the tool. The interviews (which took 30-60 minutes each) were transcribed and analyzed through thematic analysis. Each theme was synthesized as roles and potential leverage of interactive scenario prototyping for digital experience design in practical contexts.

4.3 Findings

4.3.1 Synthesizing Multi-Scale Experiences

Nowadays, designers should consider how successive experiences can be delivered beyond the apparent aspects of products and interfaces. SketchStudio was regarded as having great potential for simultaneously dealing with multi-scale aspects involving the environment, components, and dynamics. D1 mentioned, "*Such animation is really necessary in a phase of composing entire scenarios, including, for example, getting on a plane, showing a ticket, finding a seat, and putting baggage in the overhead bin.*" Conventional service-design methods can concretize an experiential flow according to touchpoints, but they lack the visualization of the overall composition of physical artifacts and surroundings. L1 remarked

on the importance of synthesizing space, journey, and interactions: "*Here we can talk about the scene, while it shows the journey there. It also describes detailed interactions. It is very important to explain all the different scales at the same time.*"

Synthesizing multi-scale aspects of a digital experience can provide benefits to designers in various domains. A typical role of an interactive scenario is supporting intuitive communication through detailed animation including spatiotemporal dynamics and visual transitions. Creating such a scenario, however, is a resource-heavy activity. It is necessary to explore new tools that can allow designers to represent complicated dynamics on scales of space, interaction, and interface at a single glance. Beyond communication, such synthetic design can provide an advantage for idea concretization. Designers should consider numerous aspects to envision digital experiences. Sometimes, they might miss some aspects while focusing on the details of interaction or aesthetics. Creating and reviewing an interactive scenario can allow designers to naturally consider multi-scale aspects at the same time. D2 said such activities can be beneficial to prospective designers: "*It forces students to think about what the service concept is and how the service flow occurs. They should always create a scenario with the spatial context in mind.*" In line with the previous studies on scenario-based design (Dow et al., 2006; Rosson & Carroll, 2002), 2.5D interactive scenarios would play a great role for establishing high-level goals in user experience design.

4.3.2 Building Symbiotic Relationships with Other Means

Scenario prototyping can be actively adopted in the early phase of design. SketchStudio was designed to enable scenario creation using rough sketches and the basic journey in the early phases. Compared to other methods and tools, deriving visually intuitive deliverables from low-fidelity means can provide a significant advantage in the conceptual design. D2 said, "*Anyway, I have to think about which scene to show using only one cut image in the storyboarding phase… But this has the advantage of creating rough animation very quickly.*" However, the conceptual design phase is relatively short in the entire design process. The experts mentioned that designers highly value tools of which the results can be used throughout the entire process. D1 said, "*For this to be competitive, ensure users know their first effort will be used continuously until the final presentation.*"

One possible approach to extend a tool's engagement is to adopt various prototyping means according to the design process. For example, scenario prototypes can involve various high-fidelity visual elements including product renderings, interface mock-ups, and real-world photos. The experts mentioned that scenarios have often been used for final presentations although they are not a core deliverable. Scenario prototypes can be naturally evolved with other visual assets produced during a design process. D2 commented, "*If an animation is necessary as a final result, I can roughly sketch it first, and the only task I have to do later is replacing cast images.*" We also figured out that it is difficult to support all important design work in a single tool (Houde & Hill, 1997). To derive higher fidelity for scenarios, SketchStudio can import external image files, and the experts strongly suggested building synergy with an interface design tool (e.g., Sketch[6] and Adobe XD[7]). Building symbiotic relationships with specialized tools can be one of the promising strategies for adopting 2.5D interactive scenario prototyping.

[6] Bohemian B.V. Sketch. Retrieved from https://www.sketchapp.com

[7] Adobe. Adobe XD. Retrieved from https://www.adobe.com/products/xd.html

4.3.3 Reflecting the Interdisciplinary Nature of User Experience Design

Most of the experts responded that scenario-prototyping tools, such as SketchStudio, would be more effective if used by interdisciplinary teams than by professional designers. The professional design practitioners can instead use rough sketches and storyboards, which is enough to represent and understand ideas, so as to rapidly move toward the next stage. Meanwhile, user experience design for innovative products and services is usually carried out by an interdisciplinary team, so rich visualization is essential for communication with non-designers (e.g., persuading engineers and researchers or building a shared goal) in collaborative situations. D3 said, reflecting on her previous experience, "*It was very challenging to verbally convince technology teams of the flows of how to interact with the displays and how to reach the goods.*"

In addition to communication, scenario-prototyping tools can be applicable to non-designers' conceptual designs. In the industry today, lots of professionals who are not trained as typical designers are already active in various innovative projects for digital experiences. Such innovative thinkers often have difficulty visualizing their ideas. The experts highly valued SketchStudio regarding scenario creation blending 3D human characters and simple 2D images. D1 said, "*It is a very good tool for designers who have a lot of ideas but feel anxious about rendering them by hand.*" D2 added, "*For nonexperts who cannot sketch at all, it is very effective in terms of doing what they could not do before.*" To support such users, it is necessary for design tools to provide various resources for rapid prototyping. Many commercial design tools already provide various templates and high-quality premade assets for beginners. Scenario prototyping tools might be actively adopted when designers, especially nonexperts in visual representation, can get better results with less effort than they expected.

5 Discussion

From the interview study, we identified the expected roles of 2.5D interactive scenario prototyping in digital experience design practice and education. Table 3 depicts the identified leverages and limitations of rapid prototyping using 2.5D interactive scenarios. While covering the implications from the experts, there are also practical issues to be considered to facilitate the usage of SketchStudio.

Table 3. Leverages and limitations of SketchStudio

Aspect	Leverage	Limitation
Subject	Synthesizing design aspects of digital experience involving environment, components (products and interfaces), and dynamics	Lack of considering numerous, detailed circumstances derived from interactions among various users and components
Means	Supporting rapid creation of intuitive, interactive scenarios with rough sketches and animations	Relatively short lifetime of rough conceptual scenario prototypes as compared with the entire design process
Usage	Helping non-designers and interdisciplinary teams to effectively design digital experiences	Need for various templates and high-quality premade assets for beginners

5.1 Aspects to Be Synthesized

The experts stressed the synthesis of multi-scale aspects of user experience. We explored visualizing various aspects of digital experience for creating 2.5D interactive scenario prototypes using our tool. Three designers created several scenario prototypes to envision future products and systems using our tool. Based on them, we discuss how the tool can represent various aspects of scenario prototyping.

5.1.1 Sketches: Appearances and Interfaces

The sketches were originally adopted as a means to represent apparent changes of spatial objects. Background sketches and overlaid state sketches can be used to represent visual aspects, including the look and feel of physical artefacts themselves as well as their interfaces (e.g., physical buttons and screens). Such sketches can also be used to illustrate invisible information, such as the auditory response of systems (Figure 4a). Sketches are flexible means, so that one can be emphasized with color and quality to distinguish from others. Thus, they can be used in different fidelities to effectively indicate the dynamics throughout the scenario scenes.

5.1.2 Scripts: Contextual Information

In addition to visual aspects, implicit information can play a great role to deliver sophisticated contexts for scenario prototypes. For instance, speech and thought bubbles (Figure 4b), which are often used in conventional storyboarding, can deliver conversations among people as well as the emotional states of users. In SketchStudio, sketches involving in human characters have the potential to express scripts for supplementing the implicit experiential context instead of visualization of the physical surroundings.

5.1.3 Gestures: Interactions and Manipulations

Animated actions, carried out by 3D human characters, can be used to describe interactions with a certain object, as shown in Figure 4c. They can intuitively illustrate gestural interactions including mid-air and touch gestures. When they are combined with appropriate sketches (e.g., handheld devices), the experiences of usage can be effectively represented. However, the actions are limited in accurately delivering a user's manipulation in terms of expressiveness. For instance, it is challenging to precisely represent which button on the screen was selected using the character actions.

5.1.4 Movements: Spatiotemporal Dynamics

In scenario prototyping, locations of elements and their spatial relationships are significantly important. The close gathering of people and artifacts can represent a situation of their interactions. Such spatial grouping can be composed as a single event—like a scene in storyboarding—to manage the experience flows. Each grouped location can signify distinct experiences, like touchpoints in service design (Figure 4d). The movement of people can manifest the flow of experience along such groups. Meanwhile, the movement can also play a role to ventilate the surroundings. For instance, conceptual stages, which do not reflect the realistic distances, can also be located in virtual space to represent scenario flows.

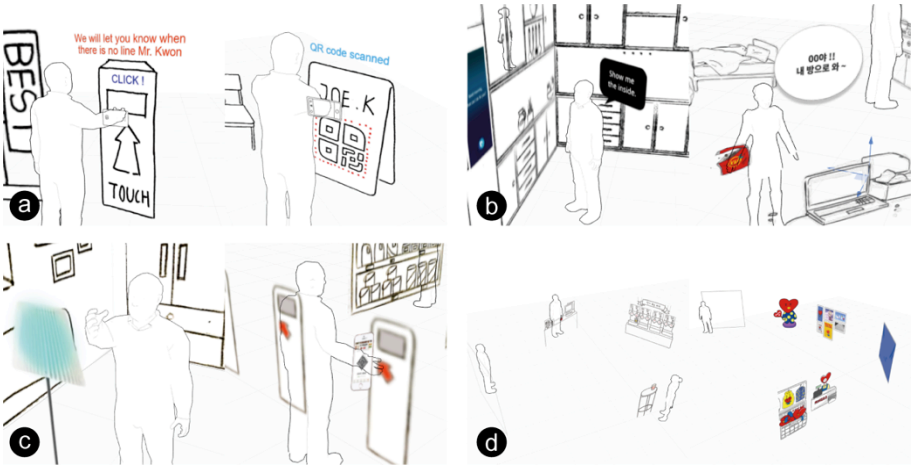

Figure 4. Aspects of scenario prototypes visualized using SketchStudio: (a) invisible information, (b) speech bubbles, (c) gestural interactions, and (b) spatial groups.

5.2 Applicable Domains

5.2.1 Reflective Design Education

Scenario prototyping has a great potential to be used as a means for training design. As the experts mentioned, scenario creation through considering various aspects can let students naturally learn how to deal with multi-scale perspectives. It also helps students keep understanding target users in reflective design activities. Meanwhile, the design scenario itself can be an effective medium for communication in educational contexts. Conventional university design courses involve design critiques in which an instructor discusses deliverables with a group of students. In such a critique, the interactive scenario prototypes can be used to precisely deliver ideas and stimulate constructive discussions. It is necessary to investigate the impact of interactive scenario prototyping through further case studies of actual design courses.

5.2.2 Appropriate Design Subjects

We present SketchStudio for scenario prototyping of digital experiences involving multiple users and digital artifacts. A promising subject is a smart environment (e.g., smart homes and public facilities) that involves various smart devices and multi-user interactions in a certain physical space. A scenario prototype is one of the most flexible and versatile means for design, so our tool also has the potential to be adopted for various design domains. Another possible application domain is layout design, including interior design and architecture. Beyond considerations of technology, the feature of configuring spatial attributes itself, involving the movement of people and the placement of objects, can be useful for the initial design of such spatial subject matter. In addition, our tool can be used for narrative design, such as film, theater, and performance. Such subjects also involve actors and stages that can be rapidly concretized using our tool. The scenario-prototyping tool is expected to enhance communication between producers and staff in rapid and intuitive ways, compared to conventional storyboards and animatics.

5.3 Limitations and Future Works

In this research, we deployed a usable prototyping tool for creating 2.5D interactive scenarios and investigated its roles and applicability. Based on the interview study, we identified several directions for improving our tool. To support effective scenario prototyping,

future works to find a connection with other visual design tools and to develop useful, exemplary assets can be considered. Meantime, this study has a limitation in evaluating the actual impact of the tool in practical domains. The experts partially used the tool during the limited interview time and then discussed while reflecting on their previous experiences. It is necessary to evaluate the tool's capability and usability as in other tool design studies. For the next step, a further study investigating case studies regarding how the tool can affect designers and their activities in the wild can be carried out.

6 Conclusion

In this paper, we present a 2.5D interactive scenario prototyping tool for digital experience design practice and education. The tool enables designers to concretize and deliver ideas of such experience involving multiple users and artifacts using 2D sketches and 3D human characters in a virtual world. This work reveals the practical roles and potential leverage of 2.5D interactive scenarios from the interview study with design experts. We also discuss further issues for the tool's applicability and engagement regarding scenario prototyping. This work contributes to design by providing a readily usable tool for various experience design projects. We expect that this tool and implications from the study will benefit digital experience design for future products, systems, and services.

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